Resilience and sustainability of the human-ocean coupled system – beyond the Great East Japan Earthquake

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Today’s Topics

1. **Sato-yama** and **Sato-umi** in Japan
   - As a concept of Human-Natural coupled system
     for maintaining biodiversity and for sustainable use of ecosystem services

2. Effects of the Great East Japan Earthquake
   - on marine ecosystems and their recoveries
     - Damage to fisheries and marine ecosystems,
     - Radioactive contamination,
From CCCC to FUTURE

How respond the North Pacific ecosystems to climate changes?

CCCC  Climate Change and Carrying Capacity (1995-2009)
Sardine, Walleye pollock, Pacific salmon
Offshore/Basin scale study

How to achieve the sustainable use of the services from the North Pacific ecosystems?

CBD, CoML, IPCC-AR4

FUTURE

Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems (2009-)

Exotic species, HABs, Biodiversity, Human dimension
Coastal/Regional scale study
Human activities:
- Must be limited to the range of the resilience of ecosystems.
- Means of the regulation of ecological succession (= maintaining a mosaic of diverse habitats) through the moderate ecological perturbation and disturbance.
Sato-yama: A Traditional Human-Natural Coupled System in Japan

*Sato-yama:* A secondary forest (*yama*) nearby a village (*Sato*) in an original sense.

*Sato-yama* has been managed as a commons of the village for the collection of firewood, fertilizer, and foods, such as nuts and mushrooms.
Sato-yama-Its Structure & Functions

*Sato-yama:* A plural ecosystem including various habitats

- Human activities
  - Agriculture/Forestry prevent the ecological succession.
- Preservation of each habitat
- Maintain Biodiversity and Ecosystem Services of *Sato-yama*

Illustration: Shiga Prefecture

Illustration: http://www.cgr.mlit.go.jp/ootagawa/sand/west/plants/forest/3b/index.htm
Sato-umi – A Concept of Human-Ocean Coupled System

Sato-umi: A coastal area where biological productivity and biodiversity has increased through human interaction

“Umi” = sea

(Ministry of the Environment)

Photo: Kyoto Prefecture/ National Federation of Fisheries Co-operative Associations
Sato-umi-Its Structure

An Image of the Structure of Sato-umi

- Rocky shore & Seaweed bed (Shellfish/Seaweed Collection)
- (Common fishing ground for fish & shellfish)
- (Aquaculture)
- Shellfish collection
- Common fishing ground for fish & shellfish
- Tidal Flat
- Sand & Mud Flat & Seagrass bed
- Sandy beach
- Village
- Farmland
- Littoral Forest

“Sato-yama”

“Sato-umi”
Institutional Base of Sato-umi

Coastal Fisheries Management by Fishing Rights

**Fishing Rights:**
- Exclusive rights granted by the Government to engage in specific fisheries in public waters.
- Fishing ground of this fisheries is a commons for fishers who live in the village near the fishing ground.

Control of the excessive entry to fisheries
Restraint to overexploitation in coastal areas
Characteristics of Japanese-style Coastal Fisheries Management

- Voluntary efforts of fishers based on their agreement
  Area & Time Closure/Catch & Effort Control/
  Size & Sex Limitation

- Integrated implementation with Stock Enhancement and
  Improvement of Fishing Ground

- Release of seeds
  Fukushima Pref.

- Developing Seaweed
  Fisheries Agency

- Plowing Sea bed
  Fisheries Agency

- Reef for Spawning & Nursery
  Kagoshima Pref.

- Clean up Beach & Fishing Ground
  Nippon Zaidan
**Sato-umi-Its Functions**

- **A Mosaic of Different Type of Habitats**
  - Interaction with Coastal Land Area
  - Degradation/Advancement

- **Rich in Biodiversity**
  - High Capacity for Regulating Environment
    - Biogeochemical cycling/water purification/etc.
  - High Biological Productivity

- Co-existence of Various Type of Fisheries
  - Stability and Sustainability of Fisheries and Local Community

- Protection & Improvement of Coastal Environment
- Coastal Development
- Restriction of Coastal Development
- Fisheries management
  - Stock enhancement
The Great East Japan Earthquake

1. Date and time: 14:46, March 11, 2011
2. Hypocenter: 38°6.2’ N, 142°51.6’E
3. Depth: 24km
4. Magnitude: M9.0

Data: The Coastal Engineering Committee of the Japan Society of Civil Engineers
Changes in Topography with the Earthquake

Contour interval: 0.5 m

Subsidence

Uplift

Vertical deformation calculated from slip distribution model

Data: Geospatial Information Authority of Japan

Mouth of Kitakami River
March, 1985

April 17, 2011

Photo: Miyagi Prefecture
## Damage to Fisheries

### Damage from the Great East Japan Earthquake to the fisheries in Japan  (as of July 5, 2012)

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Damage</th>
<th>Amount of Damage*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishing vessels</td>
<td>28,612</td>
<td>1,822</td>
</tr>
<tr>
<td>Fishery harbor facilities</td>
<td>319</td>
<td>8,230</td>
</tr>
<tr>
<td>Aquaculture facilities</td>
<td>-</td>
<td>738</td>
</tr>
<tr>
<td>Aquaculture products</td>
<td>-</td>
<td>597</td>
</tr>
<tr>
<td>Common use facilities</td>
<td>1,725</td>
<td>1,249</td>
</tr>
<tr>
<td><strong>Subtotal</strong>*</td>
<td><strong>12,637</strong></td>
<td></td>
</tr>
</tbody>
</table>

* 100 million \$

- Almost damages were occurred in 7 prefectures from Hokkaido to Chiba. \((12,544 \times 100 \text{ million } \$)\)
- Seafood processing facilities in 7 prefectures were also damaged. \((1,639 \times 100 \text{ million } \$)\)

Data: Ministry of the Agriculture, Forestry and Fisheries
Effects to Sea grass bed and Tidal flat

Changes in sea grass bed
(Same-no-ura/Ishinomaki City)
Data: Dr. Daisuke Muraoka/FRA

Changes in number of Species of Benthic organisms in taidal flats
Data: Dr. Takao Suzuki, Univ. Tohoku/Ministry of the Environment
Effects to Seaweed Bed

- **Crustose Coralline Algae (CCA)**: 5 - 7 m
- **Algal Turfs (AT)**: 4 - 5 m
- **Kelp Bed (KB)**: 2 - 4 m

*Data & Photo: Dr. Hideki Takami/FRA*
Changes in the densities of abalone and sea urchin between before and after the tsunami

Abalone

Sea urchin

Type of Seaweed Bed

KB : Kelp Bed/AT : Algal Turfs/CCA : Crustose Coralline Algae
Effects to Offshore & Migratory Species

Distribution of walleye pollock

Before
Apr. 2006-2010(Av)

After
Apr. 2011

Stock in weight of Pacific cod by age

- There was no significant deference between before and after the earthquake.

Data: Y. Narimatsu et.al./FRA (unpublished)
# Radioactive Contamination

## Estimated Amount of Radioactive Materials into the Ocean
(as of May 2012, Data: TEPCO)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Period of Assessment</th>
<th>Released amount in PBq</th>
<th>I-131</th>
<th>Cs-134</th>
<th>Cs-137</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEPCO</td>
<td>Mar. 26 - Sept. 30</td>
<td>11</td>
<td>3.5</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>JAEA</td>
<td>Mar. 21 - Apr. 30</td>
<td>11.4</td>
<td>-</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>IRSN</td>
<td>Mar. 21 - Mid-Jul.</td>
<td>-</td>
<td>-</td>
<td>27</td>
<td></td>
</tr>
</tbody>
</table>

**Half-life:** I-131=8 days, Cs-134=2 years, Cs-137 = 30 years, PBq=10\(^{15}\)Bq

**Method:**

TEPCO/JAEA: Calculate the amount of radioactive materials using a diffusion model so as to reproduce the concentration in seawater near the discharge canals of the power plant.

IRSN: Draw a contour map of the Cs-137 concentration in the North Pacific Ocean off Fukushima Prefecture, and then calculate the total amount of Cs-137.

TEPCO: Tokyo Electric Power Company /JAEA: Japan Atomic Energy Agency
IRSN: Institute de Radioprotection et de Sûreté Nucléaire
Concentration of Radioactive Materials in the Seawater near the Fukushima Dai-ichi NPP

St.T-1: North of discharge channel of 5-6 of TEPCO Fukushima Dai-ichi NPP

Data: MEXT
Cs-137 concentration of sea water around Japan for 1964-2010 and off Fukushima for 2011-2012

Data: MEXT/Meteorological Res. Inst.(Dr. Aoyama)
Concentration of Radioactive Cesiums (Cs-134 +Cs137) in Marine Organisms-1

**Surf clam/Abalone**

- Biological half-life = 50 – 140 days

**Brown Algae**

- Decrease Cs conc. in Sea water
- Decreased to low or undetectable levels

**Whitebait (sand eel)**

**Japanese sardine**

Data: The Fisheries Agency
Concentration of Radioactive Cesiums (Cs-134 +Cs137) in Marine Organisms

**Slime flounder** (*Microstomus achne*)

- Some benthic fishes and other organisms in some areas remain relatively high levels

**Japanese flounder** (*Paralichthys olivaceus*)

- **food habits:**
  - carnivorous cod, flounder
  - omnivorous greenling, black sea bream
- **Osmoregulatory ability:**
  - euryhaline perch, black sea bream
Tsunami Debris – Type and Abundance

- About 5 million tons of debris from Iwate, Miyagi and Fukushima Prefectures washed out by the tsunami.
- Its 70% (3.5 million tons) deposited on seabed along the coast of Japan, and the remaining 30% (1.5 million tons) became floating debris.

<table>
<thead>
<tr>
<th>Type</th>
<th>Floating Debris</th>
<th>Debris on Seabed</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houses</td>
<td>1,336</td>
<td>2,783</td>
<td>4,119</td>
</tr>
<tr>
<td>Cars</td>
<td>-</td>
<td>313</td>
<td>313</td>
</tr>
<tr>
<td>Driftwoods</td>
<td>199</td>
<td>-</td>
<td>199</td>
</tr>
<tr>
<td>Ships</td>
<td>1</td>
<td>101</td>
<td>102</td>
</tr>
<tr>
<td>Aquaculture facilities</td>
<td>-</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Fixed fishing nets</td>
<td>-</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Cargo containers</td>
<td>-</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,536</strong></td>
<td><strong>3,266</strong></td>
<td><strong>4,802</strong></td>
</tr>
</tbody>
</table>

Data: Ministry of the Environment
Influences of Floating Debris

1. Ecological Influences:
   - Effects to Highly Migratory Species = accidental ingestion/tangle to organisms/ghost fishing
   - Pollution of Coastal Environment
   - Transport & Diffusion of Exotic Species

2. Influences to Ship Navigation and Fishing Operations:
   - Collision with ships/Tangle to Ships’ propellers and fishing gears

3. Other Influences:
   - Damage to coastal landscape by debris

Photo: The Aquatic Nuisance Species (ANS) Task Force

Photo: U.S. Navy/AFLO/ZUMA Press
Debris Drift Prediction

Subsurface type
Specific gravity = 1.0

Lumber type
S.g. = 0.5

Float type
S.g. = 0.33

Feb. 2012

Jun. 2012


Feb. 2013

Data: Ministry of the Environment
1. Ecological Impacts:
   • Offshore region/Migratory species - Small or Negligible.
   • Coastal ecosystems – Large. Take a long time to recover. Long-term monitoring and attention to ecological succession are required.

2. Radioactive contamination:
   • Radioactivity in seawater has been decreased. But, still relatively high in sediments and benthic organisms in some waters.
   • Continuation of monitoring and studies on the dynamics of radioactive materials in the ecosystem are required.
3. Floating Debris:
   - Lots of debris will drift widely in the North Pacific Ocean for several years, and arrived to the coast of the North Pacific rim.
   - Monitoring and studies on impacts on coastal/oceanic ecosystems, mitigation ways of impacts, and treatment of debris are required.

   - These subjects are common to the North Pacific Ocean.
   - International cooperation is essential for enhance the research activities and continuation of the monitoring.
   - PICES is expected to take a leading role in the planning and implementation of the international cooperation.
I would like to express our sincere thanks for the warm sympathy and strong aid from the PICES member countries and from all over the world in response to the terrible disasters of the Great East Japan Earthquake.

PICES and ICES kindly donated CD$55,100 to aid the marine science in the disaster area. This donation was distributed to 11 research projects through the Japanese Society of Fisheries Oceanography and strongly support the ecological studies in the area. The results of the projects will be summarized and presented in this Annual Meeting (S11) with our sincere thanks. The title is “General report of the projects aided by PICES/ICES/JSFO fund for fisheries and oceanographic research on the recovery from the Great East Japan Earthquake”
This presentation is based on the studies conducted by many institutes, universities, and scientific societies, including the Fisheries Research Agency (FRA). I would like to express my sincere thanks and respects for their earnest activities.

I would like to express my deepest thanks to Drs. Kaoru Nakata, Hiroaki Saito, Shin-ichi Ito, Mitsutaku Makino, Toyomitsu Horii, Daisuke Muraoka, Hideki Takami, Takami Morita, Hideki Kaeriyama, Tomowo Watanabe, and Hiroya Sugisaki for their kind support during the preparation of this presentation.
Tank you very much for your kind attention.